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Building a Successful Machine Safeguarding Program

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Building a Successful Machine Safeguarding Program

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Introduction

Safeguarding hazards associated with machines is a goal common to all health and safety professionals. Whether the individual is new to the safety field or has held associated responsibilities for a period of time, safeguarding personnel who work with or around machine tools and equipment should be considered an important aspect of the job. Although significant progress has been made in terms of safeguarding machines since the era prior to the organized safety movement, companies continue to be cited by the Occupational Safety and Health Administration (OSHA) and workers continue to be injured, even killed by machine tools and equipment. In the early 1900s, it was common practice to operate transmission machinery (gears, belts, pulleys, shafting, etc.) completely unguarded. At that time, the countersunk set screw used on shafting had not been invented and projecting set screws were involved in many horrific accidents (Blake, 175). Manufacturers built machines with little regard for worker safety. Workers were killed or seriously injured before definitive actions were taken to improve safety in the workplace. Many states adopted legislation aimed at requiring machine guarding and improved injury reduction. The first patent for a machine safeguard was issued in 1868 for a mechanical interlock (Brauer, pg 147). Other patents followed. As methods for safeguarding machinery and tools were developed, standards were written and programs were set up to monitor factories for compliance. Many of those standards continue to govern how we protect workers today.

It is common to see machine tools built in the forties, fifties and sixties being used in machine shops today. In terms of safeguarding, these machines may be considered poorly designed, improperly safeguarded or simply unguarded. In addition to the potential threat of an OSHA citation, these conditions expose the operator to serious hazards that must be addressed. The safety professional can help line management determine workable solutions for these problems.

Your Role as the Safety Professional

The role of the safety professional is to periodically monitor operations and advise line management with regard to what they need to do. “Safety” is owned by line management. The responsibility to enforce the program belongs to line management – not the safety professional. Safety professionals who place themselves in the position of enforcing the safety process become thought of as the safety cop and will find it more difficult to maintain credibility and support among the workforce. They will find themselves held accountable by their manager for something they cannot control. It is important to your success to recognize the scope of your role.

External and Internal Enforcement

External enforcement actions, in terms of compliance inspections are performed by the Occupational Safety and Health Administration (OSHA); either State or Federal depending on the location. Federal OHSA requirements for machine guarding are located in 29 CFR 1910, Subpart O, Machinery and Machine Guarding. The requirements are contained in 1910.211 through 1910.219. In spite of the progress made in the area of safeguarding machinery and equipment, OSHA continues to identify violations at an alarming frequency. One reason may be the vast array of hazards that employers are responsible to identify. The responsibility is made clear in 1910.212(a)(1) which states that one or more methods of machine guarding shall be provided to

protect the operators and other employees in the machine area from hazards such as those created by the point of operation, ingoing nip points, rotating parts, flying chips and sparks. The standard states what must be done (the provision of one or more methods of machine guarding) but does not state how to do it. Federal OSHA data for the period October 2001 through September 2002 indicate that machine guarding standards accounted for five of the 13 most frequently cited OSHA standards. The twenty most frequently cited standards (for the period referenced) are shown in Table One. Standards related to machine guarding are highlighted.

Table One

Standard	# Cited	Description
1910.1200	3,344	Hazard Communication
1910.147	3,166	Control of Hazardous Energy, LOTO
1910.134	2,549	Respiratory Protection
1910.212	**2,403**	**Machines, General Requirements**
1910.305	1,998	Electrical, Wiring Methods
1910.219	**1,716**	**Mechanical Power Transmission Apparatus**
1910.303	1,390	Electrical Systems Design
1910.178	1,377	Powered Industrial Trucks
1910.217	**1,195**	**Mechanical Power Presses**
1910.95	1,130	Occupational Noise Exposure
1910.213	**1075**	**Woodworking Machinery Requirements**
1910.132	1,061	Personal Protective Equipment
1910.215	**1003**	**Abrasive Wheel Machinery**
1910.23	939	Guarding Floor and Wall Openings
1910.146	847	Permit-Required Confined Spaces
1910.157	818	Portable Fire Extinguishers
1910.266	742	Pulpwood Logging
1910.22	711	Walking-Working Surfaces
1910.107	698	Spray Finishing With Flammable/Combustible
1904.106	691	Flammable and Combustible Liquids

"Table One: This is a partial list from Federal OSHA, 10/01 thru 9/02"

Any of the following potential situations in a work area may be cited as a violation of OSHA standards for machine guarding (Kavianian, H. and Wentz, C. pg. 10):

- Contact with a moving part during normal operation of the machine
- Clothing getting caught in any moving part of the machine
- Random ejection of material during normal operation
- Controls not easily reached for emergency shutoff
- Operator able to bypass the guards
- Not enough space provided for operation and maintenance
- Insufficient illumination in the area
- Inadequate ventilation for machines that generate dusts, fumes, vapors, mists, or gases
- Poor housekeeping in machine shop area

In many instances, citations are issued because the appropriate safeguard has not been provided or the safeguard is not in use by the operator at the time of inspection. In other instances, interpretations of what the standard calls for may vary among OSHA inspectors. This

situation may occur more frequently for organizations that operate in multiple states. Safeguarding efforts considered to be adequate in one locale may be considered inadequate in another due to the interpretation of the standard. The safety professional needs to be familiar with practices in various regions to help their organization avoid unnecessary citations and associated penalties. The fundamental principle, safeguarding the worker must be the overriding objective of the safeguarding process at all times and the safety professional should strive to provide a consistent level of protection at each location.

As safety professionals, we monitor operations to help line management implement the safety process. It is part of our duty to help the organization comply with regulatory requirements and prepare for outside inspections. With respect to safeguarding machines and equipment, deciding whether a guard is necessary may be more difficult than determining which type of safeguard to provide (DeReamer, pg. 109). The safety professional should work with line management to make these determinations when necessary. Some of the questions to be considered include:

- Is it possible for a person to come into direct contact with a moving machine part in normal production or maintenance operations?
- Are rotating or moving screws, keys, bolt heads, burrs, or other projections so exposed as to snag a worker's clothing or to inflict injury?
- If tools, jigs, or other work fixtures are required, are they stored conveniently but where they will not interfere with the work?
- Is the work area well illuminated, with additional point-of-operation lighting where necessary?
- Is ventilation adequate, particularly for those operations that create dusts, mists, vapors, fumes, or gases?
- Is the operator using personal protective equipment if the work process indicates a need for it?
- Is housekeeping satisfactory, with no debris, tripping hazards, or spills on the floor?

The answers to these questions will help the safety professional determine whether a safeguard is necessary and will help prepare the organization for outside inspections.

Just as important is our role in preparing the organization to effectively implement safety internally. Taking appropriate actions based on the questions listed above will also help the organization in the implementation of the safety process internally. Internal implementation and enforcement of safety is a more important concern to the safety professional than external enforcement. The rationale is simple – if the organization implements the safety process effectively and enforces process requirements, inspections from external agencies will serve to verify the effectiveness of the process. If the organization fails to implement and enforce an effective process, external inspections will substantiate the failure in terms of citations and monetary penalties. We own a major responsibility of helping the organization prepare for outside inspections.

The safety professional is responsible to assess operations and identify potential hazards and controls associated with machine use. He or she will be expected to write the machine safeguarding program and help the organization with it's effective implementation, including employee training. Once these responsibilities are fulfilled, the safety professional should focus their attention on helping line management manage the program. The first task to complete is an assessment of the knowledge possessed by line management relative to safeguarding machines. Next, develop a succinct training course for line management that will bring their knowledge base to a satisfactory level. Schedule *one on ones* (or meet with small groups) with line management to

walk their areas of responsibility to identify operations that present safeguarding concerns. Make this your opportunity to educate line management with regard to the hazards and controls found in their assigned areas. Help them recognize what is expected of them (and workers) so they can appropriately enforce requirements.

The need for an effective machine safeguarding program is apparent based on the number of citations that OSHA compliance officers generate every year. The risks associated with the operation of unguarded equipment include the potential for serious injury, equipment damage, increased worker's compensation costs and vulnerability to OSHA enforcement. The safety professional can use these issues to "sell" management on the value of a proactive machine safeguarding program.

It is important to prepare properly before attempting to convince management to support your safeguarding program. The safety professional should be thorough in their analysis of the problem and use both passive and active surveillance techniques to obtain the information necessary to package their proposal to management. Examples of these techniques follow.

Passive

- Review OSHA injury logs to identify incidents related to machine safeguarding
- Review pertinent injury reports to determine the causal factors related to machine safeguarding related incidents
- Tally the number of injuries, lost/restricted workdays and worker's compensation costs and assign a realistic monetary value or loss to the organization
- Review internal/external inspection records to determine the number and type of machine safeguarding deficiencies

Active

- Assess line management knowledge of safeguarding principles and requirements
- Observe worker compliance to safeguarding requirements
- Document machine safeguarding hazards using a digital camera and incorporate these photos into your presentation to management as appropriate
- Verify deficiencies cited in OSHA citations have been corrected and whether conditions continue to meet expectations
- Develop a detailed path forward to address concerns related to safeguarding workers

The next step involves scheduling time to make your presentation to management. Practice your presentation prior to delivering it and anticipate the questions you are likely to receive. Explain the anticipated benefits to the organization related to the safeguarding program. Give careful thought to which managers should be in attendance and choose a time for your proposal when those people can attend.

The Written Program

The machine safeguarding program should be written either as a stand alone document or as a section of the overall safety manual. In either case the program should be endorsed by senior management. The written program should clearly define machine safeguarding requirements and the roles and responsibilities of employees, supervisors and management. Objectives of the program are simple; to ensure adequate safeguarding of machines and tools (and enforcement of their use) to maximize productivity and eliminate injuries.

The written program establishes the foundation of the machine safeguarding program. Elements of the written program should include:

- Purpose statement – customize to the organization/location
- Policy statement - address the use of safeguards in your organization
- Roles/responsibilities – clearly articulate roles and responsibilities for workers, first line supervisors, management and the safety professional (this element of the overall program should appear in the written program and be emphasized in the training process)
- Scope of coverage – the program should state that the requirements apply to all company-owned machine tools and equipment and all tools and equipment brought on site by contractors
- Requirements – this section can be broken down to topical areas including general, woodworking tools, metal working tools, conveyors, belts, pulleys, shafts, etc.
- Types of safeguards – describe how and where various types of safeguards are used – prohibit makeshift safeguards
- Program assessments – describe who conducts these assessments and on what periodicity, i.e., initial assignment of safety responsibilities, when new machine tools/equipment are purchased and on a periodic basis
- Training – list required training

Avoid taking the approach of writing the program, implementing it and then waiting to see what happens on the shop floor! Success is more likely if you involve a group of shop supervisors and workers in the process. This premise is also true when the action is to review an existing program. You may lead the group because of your knowledge of the standards, but your objective should be to achieve buy-in from this group prior to the new or modified program being implemented. The purpose of writing the document is to produce a program that will protect workers against injury and the organization against OSHA citations.

Other Elements of the Machine Safeguarding Program

In addition to the written program, the following elements are included in an effective safeguarding program:

- Location-specific operator qualification program – develop and implement a sitewide operator qualification program and enforce the rule that only trained, qualified operators are allowed to operate machine tools and equipment
- Work space layout – give your attention to how the shop floor is laid out and keep these principles in mind:
  - Tool room is centrally located
  - Straight line, turning, milling and grinding operations are grouped
  - Ample space is provided around tools and equipment for handling large pieces
  - Access to small spaces between machines is prevented
  - Lift-assist devices are provided and appropriately located for intended use

Understanding Safeguarding Principles and Their Use

The safety professional must understand the principles of safeguarding equipment before he or she can write a program addressing the requirements for safeguarding machines. Safeguarding principles adopted in the early 1900s are largely unchanged today. The safety professional may struggle with the application of these principles and with worker compliance, however, the principles themselves are sound and are key to improving operator safety. The principles for safeguarding have been described as follows (Hansen, 113):

1. All power working machines to have gears, sprockets, chains, belts, bands, pulleys, clutches, wheels, shafting, spindles, couplings, counter-weights, revolving or reciprocating parts and all other dangerous points, parts or projections guarded in approved manner.
2. All roller fed machines on which operator's hands come within danger zone to be guarded at the point of operation in approved manner.
3. All machines having a sheering, pressing, squeezing, or cutting action on which operator's hands come within the danger zone to be guarded at the point of operation in approved manner.

ANSI standards and OSHA standards have been written with these principles in mind. The safety professional can effectively protect the workers of the organization by basing their safeguarding program on these principles.

Some important terms to be familiar with are defined below (NSC, 382):

- Device: a mechanism or control designed for safeguarding at the point of operation, such as presence-sensing, pull-back, two-hand-trip, etc. devices.
- Enclosure: a barrier or cover that protects workers from other danger zones (other than the point of operation) in the operation.
- Guard: refers to barriers designed for safeguarding at the point of operation.
- Nip Points or Bites: a hazardous area created by two or more mechanical parts rotating in opposite directions within the same plane and in close interaction.
- Pinch Point: any place where a body part can be caught between two or more moving parts.
- Point of Operation: the area on a machine where material is positioned for processing – where work is actually being performed on the material.
- Power Transmission: includes all mechanical parts, such as gears, cams, shafts, pulleys, belts, clutches, brakes, and rods, that transmit energy and motion from the source of power to the equipment or machine.
- Safeguarding: any means of preventing personnel from coming in contact with the moving parts of machinery or equipment, potentially causing physical harm.

OSHA standards are based on the requirements of ANSI standards and are primarily directed at the hazards associated with the terms defined above. Compliance officers focus their attention to the hazards associated with these terms as they conduct a site inspection. It makes sense for OSHA inspectors to have this focus – noncompliance to requirements associated with these hazards place workers at risk of serious injury. It makes sense for safety professionals to focus attention in this area as well. If machine tools are used in your organization, employees have the potential to be exposed to serious hazards during their operation.

Machine Motions and Actions

The fundamental principle of safeguarding machines is to protect operators and coworkers from the hazards associated with the operation of those machines. As simple as that may sound, the task can be daunting. The hazards associated with machine use emanate from the mechanical motions and actions of the equipment occurring during operation. To adequately safeguard workers, the safety professional needs to first recognize the hazard and then recommend feasible solutions. The basic types of hazardous mechanical motions and actions (U.S. DOL, 2) are:

Motions

- Rotating (including in-running nip points)

- Reciprocating
- Transverse

Rotation is exemplified by turning shafts, cams, flywheels, etc. and creates the hazard of gripping gloves or clothing and pulling the worker into the machinery or placing them in a dangerous position during the operation of the machine.

Reciprocating motion describes the up-and-down or back-and-forth motion of a machine. The motion creates the hazard of the worker being caught between a moving and stationary part or being struck by the part in motion.

Transverse motion refers to movement in a straight, continuous line. This type of motion exposes the worker to being struck by the moving part or caught in a pinch point or shear point.

Actions

- Cutting
- Punching
- Shearing
- Bending

The actions of machines are somewhat more straightforward and easy to recognize. Hazards associated with machine actions occur at the point of operation where parts of the body (fingers, arms, head, etc.) can be injured. Flying particles and chips create the potential for another hazard that requires safeguarding.

Safeguards are used to make the operation of machinery safe. Some means of safeguarding equipment is necessary whenever the operation of the equipment creates a potential hazard to the operator or coworker. To be effective, safeguards need to meet certain requirements. These requirements include:

- preventing the worker from making contact with dangerous moving parts
- being made of substantial, durable material and being secured (to the equipment when possible)
- the capability of providing protection from objects falling into the moving machine
- being designed so as not to create a new hazard or operator interference
- being designed to allow for lubrication without removal of the safeguard

The safety professional should be involved in the design of safeguards and can help ensure they meet the requirements identified above. Usually, that means the safety professional should be involved by communicating with the manufacturer of the safeguard to ensure the safeguard will protect workers adequately.

Some organizations maintain the ability to construct suitable safeguards in-house. The safety professional is encouraged to evaluate the potential of increased liability for the organization before choosing to have safeguards built in-house. Equipment manufacturers and other organizations build safeguards that meet or exceed ANSI requirements and provide the needed protection to workers. It is often less expensive to purchase the required safeguards at the time the equipment is purchased; avoid the temptation to purchase the equipment without safeguards on

the promise of manufacturing them in-house. Some of the problems inherent to in-house, makeshift safeguards include:

- may not meet OSHA/ANSI requirements
- may not provide full protection for workers
- may be made from flimsy material leading to their subsequent damage
- may not fit the machine properly
- may overly impede production
- may be easily removed by the worker

Guards are usually made of metal, plastic or wood. Metal is often preferred because of it's strength and durability. Plastic is used in situations that require a higher level of visibility or when it is desirable for the operator to position the guard in relation to the work being performed. Wood guards are flammable and generally lack the durability and strength of guards made of either metal or plastic. The use of guards made of wood is limited by OSHA standard 1910.219(o)(2) as follows: Wood guards may be used in the woodworking and chemical industries, in industries where the presence of fumes or where manufacturing conditions would cause the rapid deterioration of metal guards; also in construction work and in locations outdoors where extreme cold or extreme heat make metal guards and railings undesirable. In all other industries, wood guards shall not be used.

An obvious concern with regard to the machine safeguarding program is whether the safeguards are used properly by the workers. Line management is key to enforcing program requirements. The safety professional provides assistance through periodic monitoring of work activities. Line management observes work activities on a daily basis. Monitoring the use of guards or safeguards is relatively easy because machine tools are generally used in fixed locations. The simple observation process, whether formal or informal can be an effective tool for maintaining the integrity of the machine safeguarding program. However, both line management and the safety professional must be vigilant in the recognition of noncompliance and correct situations as they are noticed. The worker will view the failure to correct at-risk work practices as passive permission by line management and at-risk work practices will continue.

The Approach to Safeguarding Machinery and Equipment

Recommending safeguards for machines and equipment is similar to recommending controls for other types of hazards. First, the hazard is identified and then an appropriate control (or controls) is recommended (the hazard should be engineered out if possible). The hierarchy for safeguarding hazards is:

- Engineering controls (guards, barriers, devices)
- Administrative controls
- Personal Protective Equipment

Effective means of safeguarding machines and equipment include:

- Guards
    - Fixed/enclosure
    - Interlocked
    - Adjustable
    - Self-adjusting

- Devices
    - Presence sensing
    - Pull back
    - Restraint (holdout)
    - Safety trip controls
    - Two hand controls
    - Two hand trip
    - Gate/cage
- Location/Distance
    - Position of the operator's control station
    - Distance the machine feeding process is away from operator's hands
- Other
    - Robotics
    - Automatic feeds

It is worthwhile to expand on each category of protection.

Guards

Fixed guards or enclosures are the preferred type of protection because they prevent access to the dangerous parts of the machine by the operator at all times. The safety professional should recommend this type of protection unless it is determined to be impractical for substantiated reasons. This type of safeguard can be applied to many types of equipment including presses, chain and belt drives, rotating shafts, reciprocating parts, and gears. The fixed guard can be adjustable to allow for the use of various tools or materials.

Interlocking guards prevent the operation of the control that places the machine into operation until the guard is moved into the proper position. An interlocking safeguard may be electrical, mechanical, pneumatic or a combination of designs. The interlocking safeguard is "open" when dangerous parts of the machine are exposed and is "closed" when the machine is in operation.

Devices

Safeguarding devices are designed to perform one of several functions aimed at protecting the operator. Devices may stop the machine when the operator's hand or other body part is placed in the danger area, restrain or withdraw the operator's hands from the danger area during machine operation, require the operator to use both hands to operate the machine or provide a barrier that is synchronized with the operating cycle of the machine to prevent the operator from coming in contact with dangerous parts of the machine during operation.

Presence sensing devices may be photoelectric, radio frequency (capacitance) or electromechanical in design and effectively stop the operation of the machine when their light field, capacitance or probe sensing mechanisms are tripped or broken.

Pullback devices make use of a series of cables which are attached to the hands, wrists and/or arms of the operator. This type of device is primarily used on machines with stroking actions such as power presses and press brakes and allows the operator to access the point of operation

between cycles. The devices automatically pull the operator's hands out of the danger area during the cycling of the machine.

Restraint devices also utilize cables or straps that are attached to the operators hands or wrists. The cables or straps must be adjusted for individual operators to ensure the operator cannot access the danger zone of the machine being operated. Hand-feeding tools are usually necessary because there is no extending or retracting action associated with this type of safeguard.

Safety trip controls allow the machine to be stopped quickly in an emergency situation. Examples of this device include a pressure-sensitive body bar and tripwire cables. Pressure-sensitive body bars are often located in front of the machine and will deactivate the machine when the operator makes contact with it. Tripwires are usually found around the perimeter of the danger area and must be located within reach of the operator.

Two-hand control systems require the operator to apply consistent, concurrent pressure to operate the machine. This feature results in the operator's hands being kept away from the danger area during the operation of the machine.

Two-hand trip devices also require concurrent pressure to each control button to activate the machine cycle. Once the cycle has been activated, the operator's hands are then free. This type of safeguard must be located far enough away from the point of operation that the operator is unable to access this area prior to the first half of the machine cycle being completed.

A gate or cage is a movable barrier designed to protect the operator at the point of operation before the machine cycle can be activated. The device must be interlocked to prevent activation of the machine unless the device is in the proper position.

Location/distance

In some cases, workers may be safeguarded by location/distance from the hazard. In such cases, the machine may be located in such a manner that the worker is not exposed to dangerous parts during the normal operation of the machine. An example of this method is the placement of a machine against a wall so that the operator is isolated from the power transmission components of the machine. In other cases, the operator's control station may be located a safe distance away from the machine. Workers may be adequately safeguarded, by distance, in cases where material stock several feet long is being worked on one end while the operator holds the other end. Formulas are found in the OSHA standards that help the safety professional determine the minimum distance (from the hazard) for adequate safeguarding.

Other

Robots have become more common in the workplace in recent years. Robots, in effect safeguard workers by performing many repetitive, highly hazardous and unpleasant jobs. The safety professional must recognize that the use of robotics in the workplace also presents hazards to the human worker including those hazards categorized as "struck by" and "caught between". The hazards associated with robotics must be assessed and properly safeguarded.

Semi-automatic and automatic feeds can reduce the worker's exposure to hazards during the machine operation by eliminating the need to reach into the danger area when feeding stock material into the machine. Examples of this type of safeguard can be found on various types of power presses and other production machinery.

The approach taken by the safety professional in terms of the safeguards recommended should protect both the operator and coworkers. Caution should be used to ensure the recommended control does not overly impede the operator's ability to perform their job. The safeguard must be substantial and capable of protecting personnel.

Safeguarding the Point of Operation

Workers who operate machine tools and equipment face a variety of potential hazards associated with belts, pulleys, shafts, gears, projecting parts and the point of operation. The safety professional must identify satisfactory controls for each of these concerns.

The point of operation, as previously defined refers to the area on a machine where work is actually being performed. It makes sense for the safety professional to focus attention to this area because operators are usually focused on the work they are performing and the point of operation often creates a serious injury hazard when the machine is functioning.

More than fifty years ago Heinrich (Heinrich, 227) cited seven principles related to point-of-operation guarding. These principles continue to make sense today. The seven principles are:

- Designing and constructing tools so that guards are not required
- Providing enclosures, covers and barricades
- Providing mechanical feeding devices
- Providing devices that prevent or interrupt the movement of tools when the operator's hands are in the danger zone
- Providing remote-control operating mechanisms
- Providing mechanical devices that remove the hands from the danger zone
- Combinations of devices

Heinrich suggested that prospective safety professionals would profit by carefully studying and memorizing the list of principles for safeguarding the point-of-operation. Although Heinrich firmly believed that human failure was the major cause of industrial accidents, he recognized that proper safeguards would make the work area a safer environment. The application of one or more (in combination) of these principles will improve shop safety.

Where to Look for Hazards

Machine and/or equipment hazards exist in nearly every type of organization. The safety professional and line management should complete a detailed assessment of facilities and operations to identify safeguarding concerns. Basements, mechanical rooms, rooftops and other out of the way places should be included in the assessment process. Table Two below illustrates typical machines/equipment and hazards found in various areas of an industrial facility.

Table Two

Location	Machines/Equipment	Hazard
Machine Shops	Metalworking tools including shears, brake presses, drill presses, lathes, mills, grinders, etc.	Machine motions and actions, shafts, belts, pulleys, flying objects
Wood Shops	Woodworking equipment including tablesaws, bandsaws, lathes, vertical skilsaws, planers, jointers, drill presses, etc.	Machine motions and actions, shafts, pulleys, belts, flying objects, etc.
Mechanical Rooms	Boilers, pumps, compressors	Belts, pulleys, power transmission equipment
Roofs	HVAC, Plenums, Fans	Shafts, pulleys, belts
Shipping/Receiving	Conveyor equipment	Belts, rollers, chain drives, gears
Waste Treatment Areas	Pumps, mixers, separators	Shafts, pulleys, belts
Production Packaging	Palletizers	Reciprocating, hydraulic "sweeping" arms, chain drives, belts
Production Floor	Power presses, punch presses	Machine motions and actions, shafts, belts, pulleys, flying objects, stroking action, material feeding and ejection
Production Floor	Conveyors, packages, robotics	Shafts, belts, rollers, chain drives, pinch points, nip points

"Table Two: This table describes where to look for hazards"

It is important to make your assessment thorough. Do not assess only the obvious areas in the facility and think you are through assessing your operations. The assessment process will yield the most useful results if you proceed following the "operational process path" and then walk the extraneous areas. Utilizing a systematic approach to the assessment helps ensure no areas of the facility are overlooked. Talk to the workforce during the assessment to garner their opinions relative to safeguarding concerns they may have.

The assessor should focus on the types of machine/equipment motions and actions described earlier. Any situation he or she observes that involves any of the motions or actions described earlier is a potential concern that should be noted. After examining the condition, the assessor should indicate:

- whether an appropriate safeguard has been provided
- the type of safeguard provided
- the general condition of the safeguard
- whether the safeguard was in place and operable at the time of the observation.

Deficient conditions, i.e., safeguards missing or not operable shall be promptly forwarded to the area manager for correction. The assessment is an opportune time to assess the status of

housekeeping in various areas of the organization. Poor housekeeping practices increase the likelihood of injuries; a worker who trips and falls on debris could become entangled in operating machines.

The people involved in the assessment need an understanding of company and OSHA requirements for safeguards. The safety professional can be of help to the organization by providing this type of training to those participating in the assessment.

Assessing an Existing Safeguarding Program

Whether you have just been given safety responsibilities or you have been managing safety in an organization for several years, it is a good, proactive practice to assess the safeguarding program. Accidents involving operating machinery often result in serious injury to the worker. Situations in the plant change over time; new equipment and machine tools may be added to meet production levels. The safety professional can ensure the safeguarding program is up to date and adequately protecting workers by conducting a thorough assessment on a periodic basis.

Biennial assessments are probably adequate; partial assessments can be completed at more frequent intervals if you know of changes in the operation. The safety professional should work with line management to establish the optimum frequency to assess operations. The training provided to line management should include the instruction to monitor their areas for the installation of new machine tools and equipment – and additional controls that may be needed.

Formal assessments may be supplemented by periodic meetings with line management for the purpose of refreshing them with respect to safeguarding requirements. This opportunity can be used to solicit whether any new machine tools or equipment have been purchased or are being planned for purchase.

A quick review (annually) of the OSHA injury log will help the safety professional determine if the machine safeguarding program is effective. Injuries indicate a problem exists; either a safeguard was missing, was not operating as designed, or was removed by the operator during the operation of the equipment. Line management either failed to detect the hazardous condition or failed to act on what they were told or saw in the workplace. Assessing the injury log and appropriate injury reports can help the safety professional identify weaknesses in the program and where their attention should be focused to help line management correct the problem.

Investigating the Incidents

History has demonstrated the potential severity related to incidents involving machine tools and equipment. Operators of this type of equipment are exposed to these hazards virtually every time they energize the equipment. Incident investigation is an important duty of the safety professional. In this regard, the safety professional can help line management understand the injury problem and also help them identify (and make meaningful changes to promote incident prevention) why incidents occur.

In today's work environment, safety professionals recognize that simply citing human failure as the root cause of incidents may be short-sighted. Thorough investigations of incidents look beyond symptoms to identify the true root cause(s) of the incident. The root cause is often related to the management systems in place in an organization. As Petersen noted (Petersen, 15) "an accident is an indication of something wrong with the management system." While it may be true that a worker suffered an injury while operating a machine tool after the guard had been removed, it is unlikely that the injury occurred the first time the guard was removed by an employee. It is also unlikely that the supervisor had never seen an individual operating the

equipment in this manner. Something in the culture of that organization allowed (or maybe encouraged) the operation of that machine tool in the stated condition. Petersen's point is simple: although the worker was at fault for having operated the tool in this condition (perhaps even removing the guard), it is the management system that allows the condition to exist. To fix the problem, the safety professional has to identify and address the weakness in the management system. In the example discussed above, a safety professional might cite the unsafe act as *operating the machine tool without the proper guarding in place* and the unsafe condition as *the missing guard*. In doing so, the safety professional has only identified symptoms related to the problem; his/her investigation has not determined why these conditions were allowed to exist. Weaknesses in the management system were not identified. Safety will improve when the investigation identifies the true root cause(s) and modifications are implemented to address them.

Summary

The safety professional must understand their role in the safety process. "Safety" is owned by line management; the safety professional is responsible to assist line management with the implementation of the safety process.

Safeguarding employees who work with or around machines or equipment is a concern for most safety professionals. The hazards associated with machine tools and equipment exist in nearly every industry. Whether new to the field or having managed safety for a period of time, the safety professional can benefit their organization through a careful evaluation of the safeguarding program.

The safety professional tasked with developing a safeguarding program should consider the following key steps in the process:

- systematically assess operations using both passive and active techniques to identify the hazards and controls associated with machine use
- develop a convincing presentation to propose the safeguarding program to management
- prepare the written program using input from line management and workers
- implement an operator's qualification program to control authorization of personnel to operate machines and equipment
- clearly articulate roles and responsibilities for workers, first line supervisors, management and the safety professional
- develop and implement a machine tool and equipment safeguarding training module
- assist line management in the periodic assessment of the safeguarding program

Today's safety professional is given many duties and responsibilities in their organization and it is often difficult to prioritize tasks and determine where the focus should be. Safeguarding the workers is paramount. An effective safeguarding program will prevent injuries, improve production and employee morale and favorably impact the bottom line of the organization. This is an area worthy of the safety professional's attention. Machine tool and equipment safeguarding is a subject worthy of continuous vigilance from line management and the safety professional.

References

Blake, R.: *Industrial Safety*, Fundamentals of Machine Guarding, New York, Prentice-Hall, 1914.

DeReamer, R: *Modern Safety and Health Technology*, Safeguarding Machines and Equipment, New York, Wiley and Sons, 1980.

Hansen, C.: *Universal Safety Standards*, Second Edition, New York, Universal Safety Standards Publishing Company, 1914.

Heinrich, H.:, *Industrial Accident Prevention – A Scientific Approach*, Machine, Prime-Mover and Power-Transmission Guarding, New York, McGraw-Hill Book Company, Inc., 1959.

Kavianian, H. and Wentz, C.: *Occupational and Environmental Safety Engineering and Management*, Legislation, Regulations and Standards, New York, Van Nostrand Reinhold, 1990.

National Safety Council (NSC): *Accident Prevention Manual for Business and Industry – Engineering and Technology10th Edition*, Safeguarding, NSC, 1996.

OSHA, *Concepts and Techniques of Machine Safeguarding*. Washington, D.C.: U.S. Department of Labor, Occupational Safety and Health Administration, Bulletin 3067; 1992 (revised).

Petersen, D.:, *Safety Management – A Human Approach*, Second Edition, New York, Aloray, 1988.

http://www.osha.gov/cgi-bin/std/stdser1?esize=0&state=FEFederal&sic=D – Federal OSHA table of most frequently cited standards, October 2001 – September 2002.

Additional Resources

Books

Christensen, W. and Manuele, F.: *Safety Through Design*, NSC, Itasca, IL: 1999.

Grubbs, J. and Nelson, S.: *Safety Made Easy: A Checklist Approach to OSHA Compliance*, Second Edition, Government Institutes, Rockville, MD., 1999.

National Safety Council (NSC): *Supervisor's Safety Manual*, 9th Edition, Laing, P. (project editor), Itasca, Il., 1997.

Spellman, F. and Whiting, N.: *Machine Guarding Handbook: A Practical Guide to OSHA Compliance and Injury Prevention*, Government Institutes, Rockville, MD, 1999.

Websites

http://www.ansi.org/ - Home page of the American National Standards Institute, provides information to purchase individual (ANSI B Series Standards) Machine Guarding Standards

http://www.asse.org - this is the home page of the American Society of Safety Engineers. It provides links to useful resources, information about standards and offers a variety of reference material addressing safety and health topics.

http://www.exonic.com/products+partners/main.asp - sample of an organization that manufactures motion control devices.

http://www.gov.mb.ca/labour/safety/publicat/guidelin/machine/machine.html - Canadian site providing general information about machine guarding.

http://www.labsafety.com//refinfo/ezfacts/ezf169.htm - offers a summary of OSHA machine guarding requirements.

http://www.nsc.org - this is the home page of the National Safety Council. It provides links to useful resources, information about standards and offers a variety of reference material addressing safety and health topics.

http://www.osha.gov - this is the home page of Federal OSHA and the site allows access to the Federal OSHA standards, letters of interpretation and other information useful to the safety professional.

http://www.osha-slc.gov/Publications/Mach_SafeGuard/checklist.html - OSHA Machine Guarding Checklist.

http://www.osha-slc.gov/SLTC/machineguarding/index.html - provides links to OSHA standards, interpretation letters, directives, and other compliance-related information.

http://www.rockfordsystems.com - sample of a company that produces custom safeguards and provides recognized training in the area of machine guarding.